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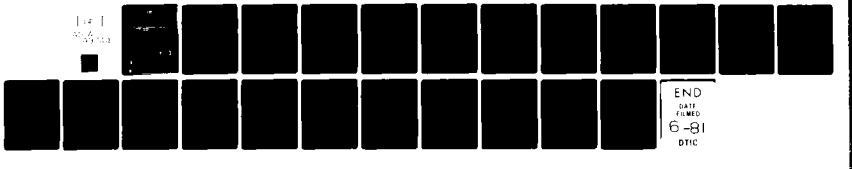

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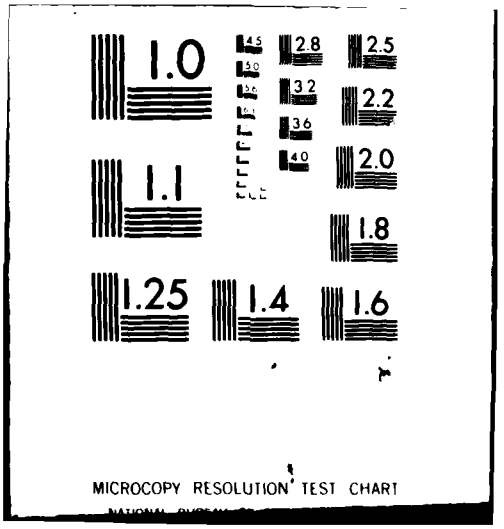
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LEVEL II

DEVELOPMENT OF ENVIRONMENTAL PROFILES FOR TESTING EQUIPMENT INSTALLED IN NAVAL VSTOL AIRCRAFT

Alan Dominitz and George Hirschberger
Grumman Aerospace Corporation
Bethpage, N.Y. 11714

May 1979

Final Report for Period 25 September 1978 — 30 March 1979
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A study recently completed by Grumman for the Naval Research Laboratory (Grumman Report No. RMS-79-R-1) developed a methodology for establishing test profiles, based on mission profiles for avionics installed in conventional (i.e., horizontal take-off or landing) Naval jet aircraft. This study was undertaken to identify differences in mission and environmental stresses between V/STOL and conventional jet aircraft. This report presents typical V/STOL missions, environmental criteria and sample test profiles for each of these missions.

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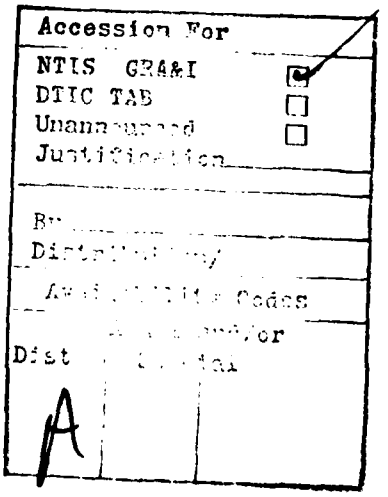
Preface

This Final Technical Report was prepared by the Grumman Aerospace Corporation, Bethpage, New York under Contract Number N000173-78-M-1391 for the Naval Research Laboratory, Washington, D.C. Mr. Lionel Moskowitz, Code 5326, was the NRL Project Engineer. The effort described was accomplished during the period, September 25, 1978 through March 30, 1979. In addition to Messrs. Dantowitz and Hirschberger, other Grumman study team members were Mr. Benjamin Steinberg and Mr. Joseph Popolo.

A study recently completed by Grumman for the Naval Research Laboratory developed a methodology for establishing test profiles, based on mission profiles for avionics installed in conventional (i.e., horizontal take-off or landing) Naval jet aircraft. This study was undertaken to identify differences in mission and environmental stresses between V/STOL and conventional jet aircraft. This report presents typical V/STOL missions, environmental criteria and sample test profiles for each of these missions.



CONTENTS

ILLUSTRATIONS

Section 1

INTRODUCTION

1.1 Background

Grumman Aerospace Corporation recently completed a 14-month study for the Naval Research Laboratory to evaluate environmental profiles for testing equipment installed in Naval aircraft (see reference). The purpose of this study was to define the precise methodology used to establish environmental test profiles, based on mission profiles, for avionics installed in Naval jet aircraft. The detailed procedures, mission profiles generated, and the associated test profiles developed were all derived from data obtained from conventional fixed wing aircraft.

The study results were only applicable to aircraft having a horizontal takeoff mode (V/STOL vehicles were not included). Since the V/STOL aircraft will play a decided role in the future of aeronautics, it was important to expand the basic study so that mission and testing profiles could be developed for vertical take-off/landing aircraft.

1.2 Study Objectives

The purpose of this study was to identify differences between V/STOL and conventional aircraft in terms of mission profiles and environmental conditions experienced.

The study has therefore been structured to include:

- Environmental differences
- Test values which encompass the environmental differences
- Typical V/STOL missions
- Sample test profiles

Reference: Evaluation of Environmental Profiles for Testing Equipment Installed in Naval Aircraft, Grumman Report No. RMS-79-R-1, dated February 1979.

Section 2

SYSTEM AND MISSION DESCRIPTION

2.1 System Description

Two types of V/STOL aircraft were investigated during this study: the "A" V/STOL and the "B" V/STOL. Each type has its own assigned role in Navy planning and consequently each has its own set of anticipated missions and design characteristics.

The "A" V/STOL aircraft is a twin engine, subsonic vehicle designed for sea control and utility type missions. Thus its missions include anti-submarine warfare, aircraft early warning, tanker, delivery, and assault functions. It can take off and land either vertically or horizontally. Vertical operations are accomplished by a rotation of the engines.

The "B" V/STOL aircraft is a twin engine supersonic vehicle. It is approximately 10,000 pounds lighter than the "A" vehicle. The "B" vehicle is designed for a fighter-attack role and thus it will perform intercept and surveillance missions. Also, it can take-off and land in either a vertical or conventional mode. The vertical mode is accomplished by use of engine exhaust deflectors.

2.2 Mission Description

Generalized missions for each type of aircraft considered are presented below. These missions represent the current view of the role envisioned for V/STOL type aircraft for the future. Each such mission is a representation of a group of missions in that it identifies elements shared in common and thus, typifies the expected operating environment. Furthermore, these missions are used as a basis for design and planning purposes.

Each mission is described by certain spatial aspects that are required in the development of the environmental test. In particular, aircraft speed and altitude enroute to the combat area, during combat, and return to the ship are identified.

Presented below are the missions, and their characteristics, for each type of V/STOL aircraft. Although each type of aircraft can take-off and land in a conventional mode, it was assumed for this study that all take-offs and landings would be performed vertically.

"A" V/STOL

- Airborne Early Warning Mission (AEW)
  (Vertical take-off; climb to altitude; high altitude cruise out, loiter and cruise back; descend; vertical landing)
- Anti-submarine Warfare Mission (ASW)
  (Vertical take-off; climb to altitude; high altitude cruise out, loiter, ordnance delivery and cruise back; descend; vertical landing)
- Contact Investigation
  (Vertical take-off, climb to altitude, low altitude dash, low altitude and low speed loiter and ordnance delivery, climb to high altitude, high altitude cruise back, descend, vertical landing)
- Marine Assault
  (Vertical take-off, seal level cruise out, hover at 3000 feet, sea level cruise back, vertical landing)
- Surface Attack
  (Vertical take-off; climb to altitude; high altitude cruise out; loiter and weapon delivery at 20,000 feet at low speed, high altitude cruise back; descend; vertical landing)
- Tanker Mission
  (Vertical take-off, climb to altitude, high altitude cruise out, loiter at low speed and low altitude to transfer fuel, high altitude cruise back, descend, vertical landing)
- Vertical Onboard Delivery Mission (VOD)
  (Vertical take-off, climb to altitude, high altitude cruise, descend, vertical landing)

"B" V/STOL

- Combat Air Patrol Mission (CAP
  (Vertical take-off, climb to altitude, high altitude cruise out and loiter combat at high speed and lower altitude, high altitude cruise back, descend, vertical landing)
- Deck Launched Intercept Mission (DLI)
  (Vertical take-off, high speed climb to altitude, high altitude and high speed dash out and combat, high altitude cruise back, descend, vertical landing)
- Subsonic Surface Surveillance Mission
  (Vertical take-off, climb to altitude, high altitude cruise out and loiter, combat at intermediate altitude, high altitude cruise back, descend, vertical landing)

Analyses were performed to determine the specific numerical values needed to describe each of the above missions. The parameters that required evaluation included:

- Phase altitude
- Phase Mach number
- Durations
- Transition rates between steady state conditions.

The resulting mission profiles developed from these analyses are presented graphically in Figures 1 through 10.

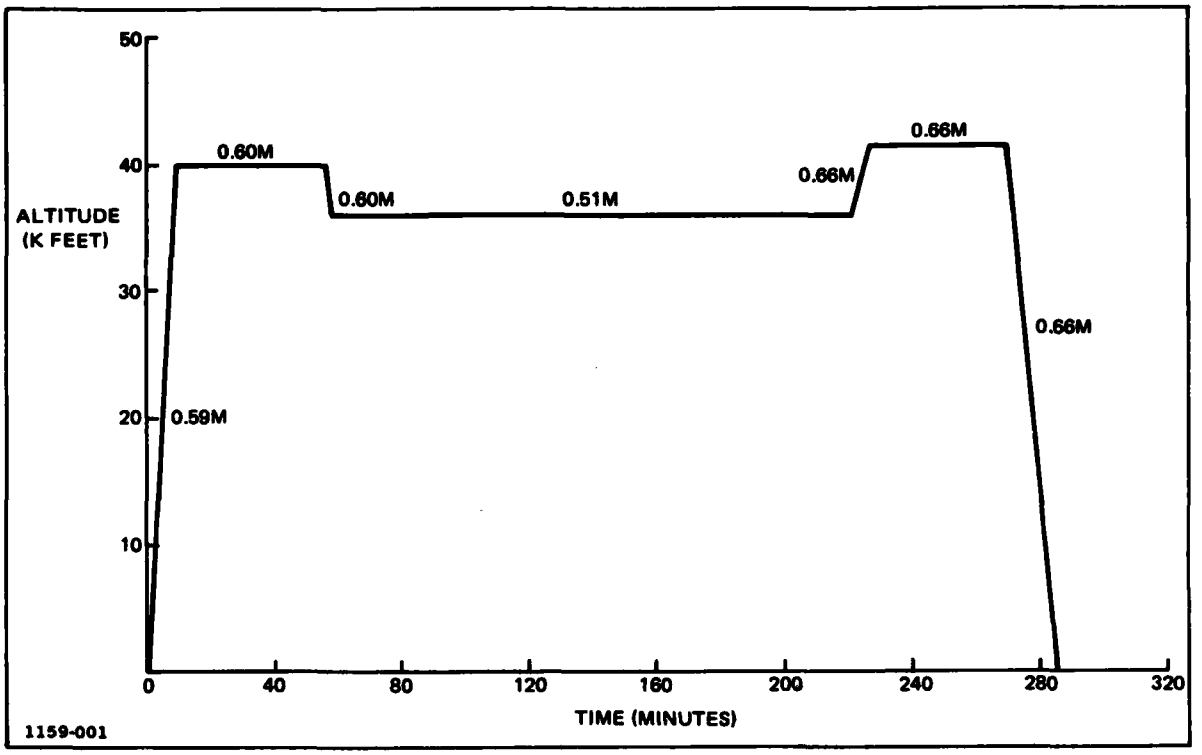


Figure 1 "A" V/STOL Airborne Early Warning Mission Profile

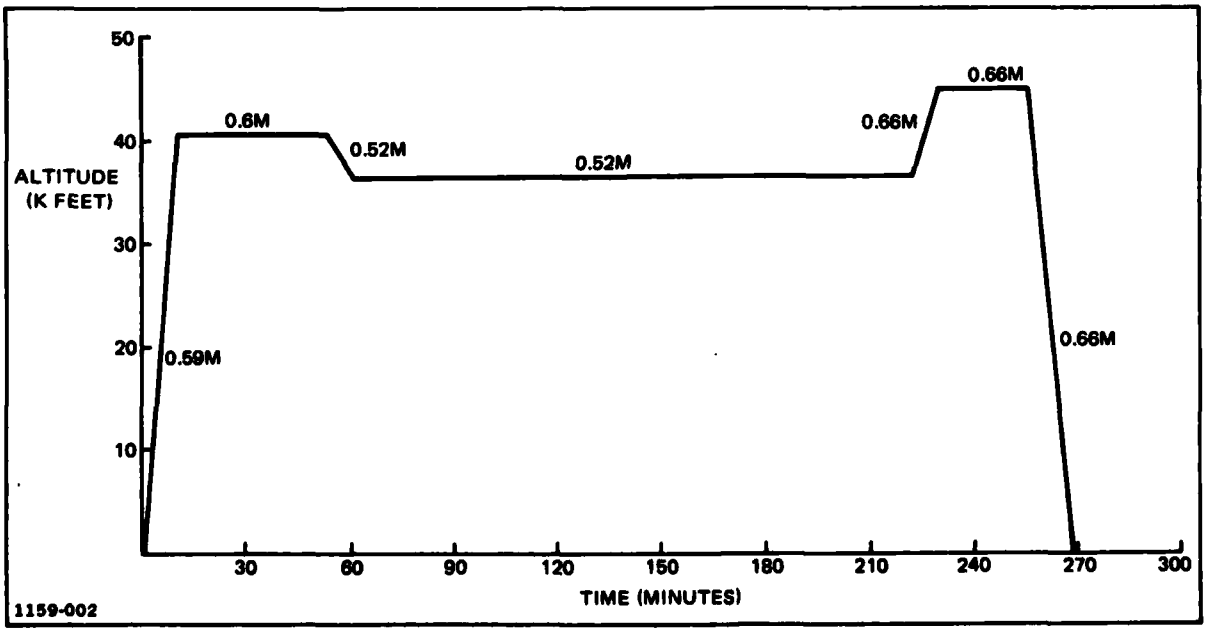


Figure 2 "A" V/STOL Anti-Submarine Warfare Mission Profile

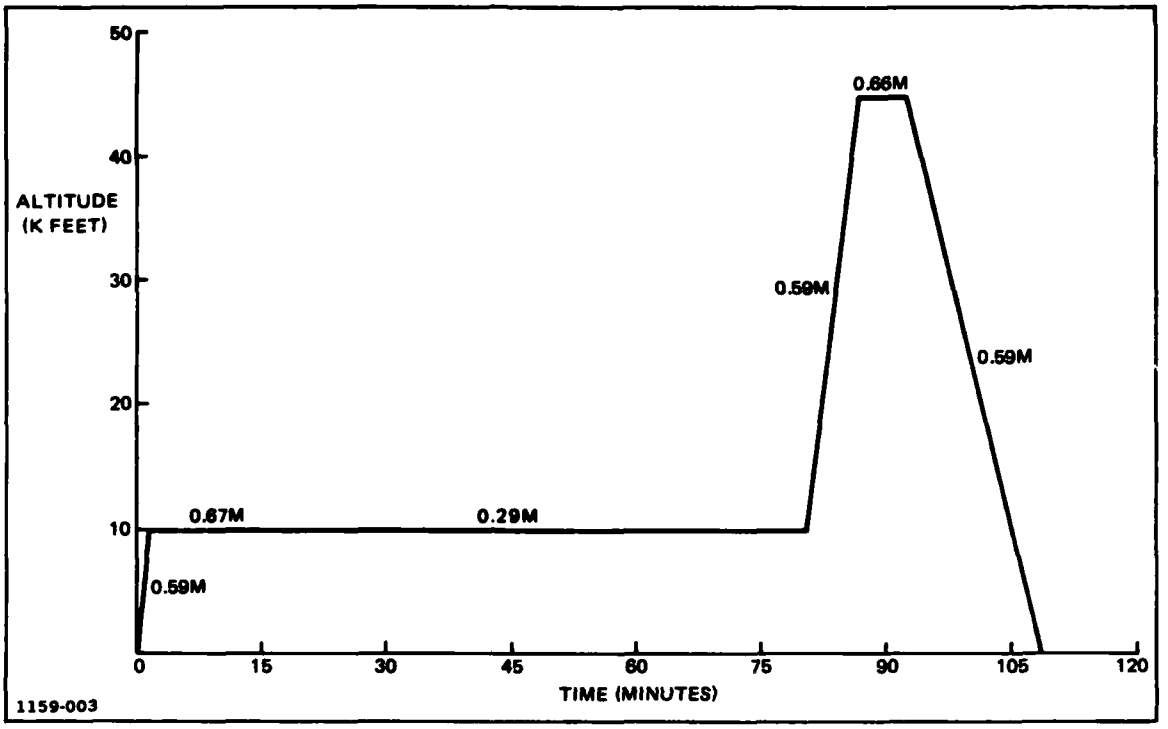


Figure 3 "A" V/STOL Contact Investigation Mission Profile

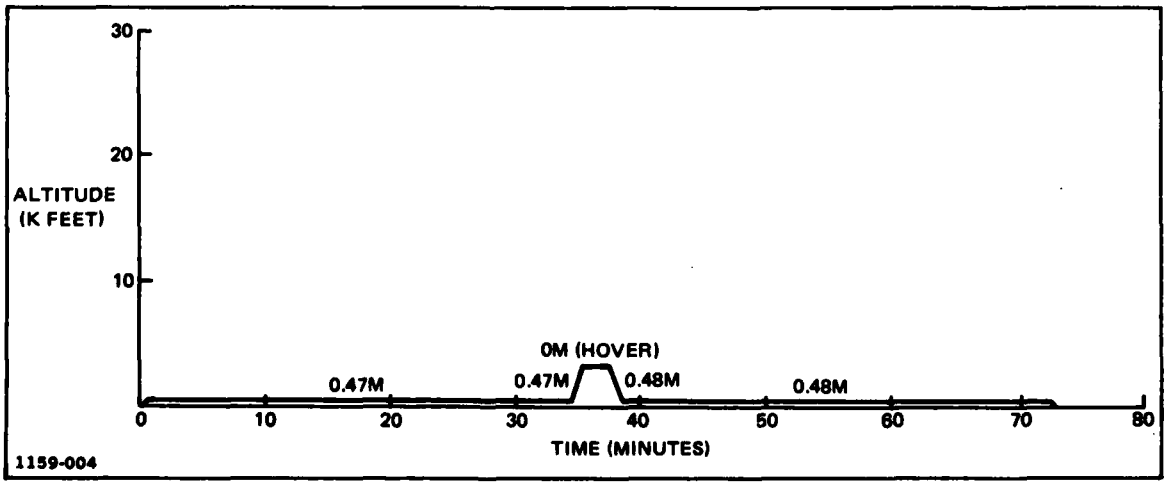


Figure 4 "A" V/STOL Marine Assault Mission Profile

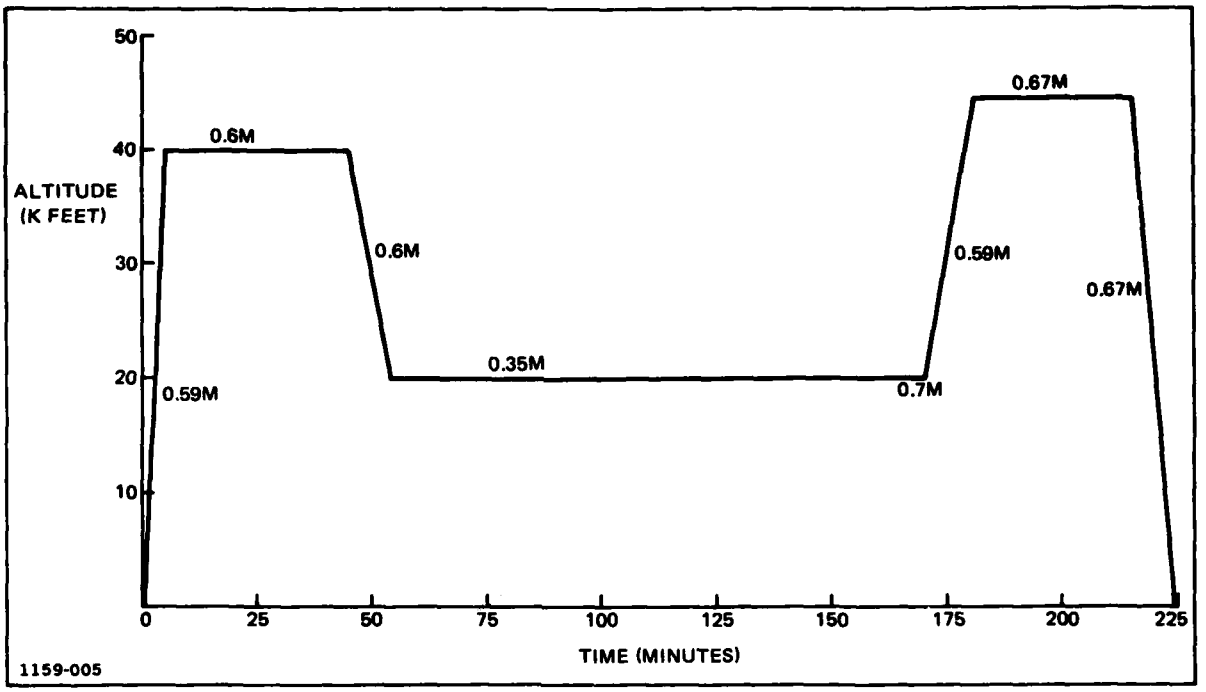


Figure 5 "A" V/STOL Surface Attack Mission Profile

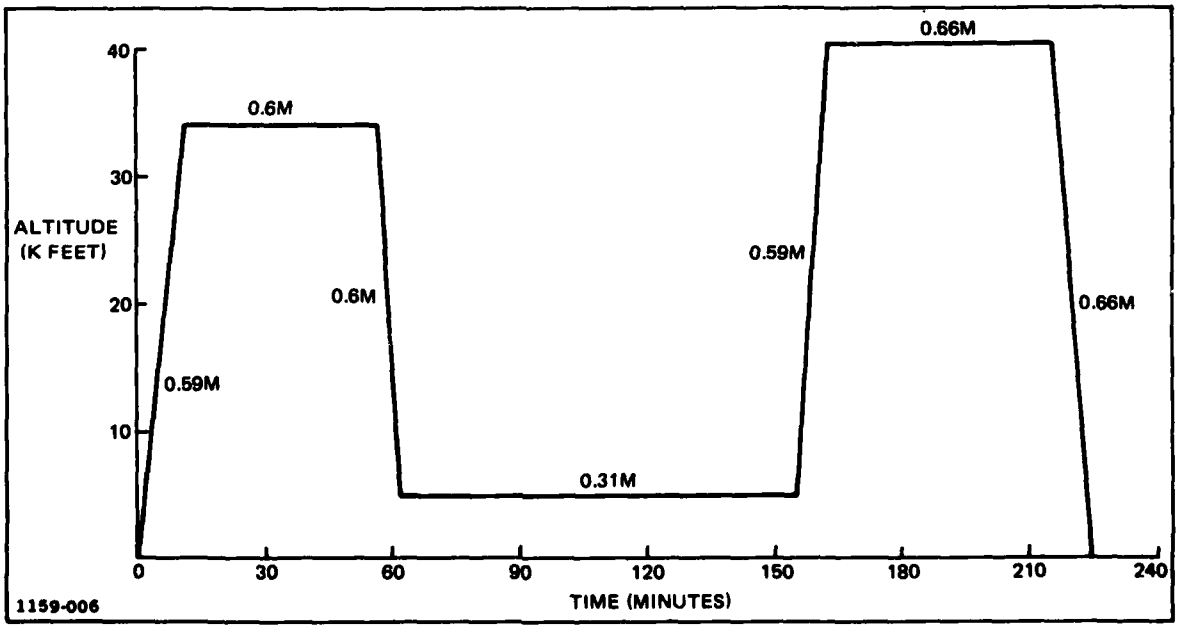


Figure 6 "A" V/STOL Tanker Mission Profile

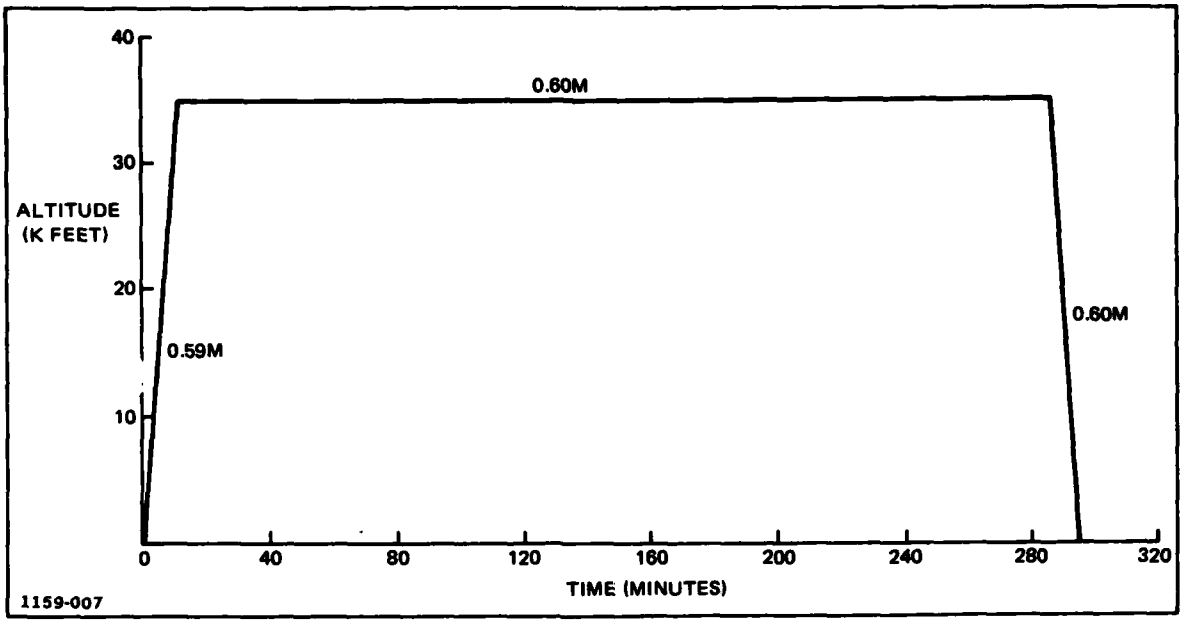


Figure 7 "A" V/STOL Vertical Onboard Delivery Mission Profile

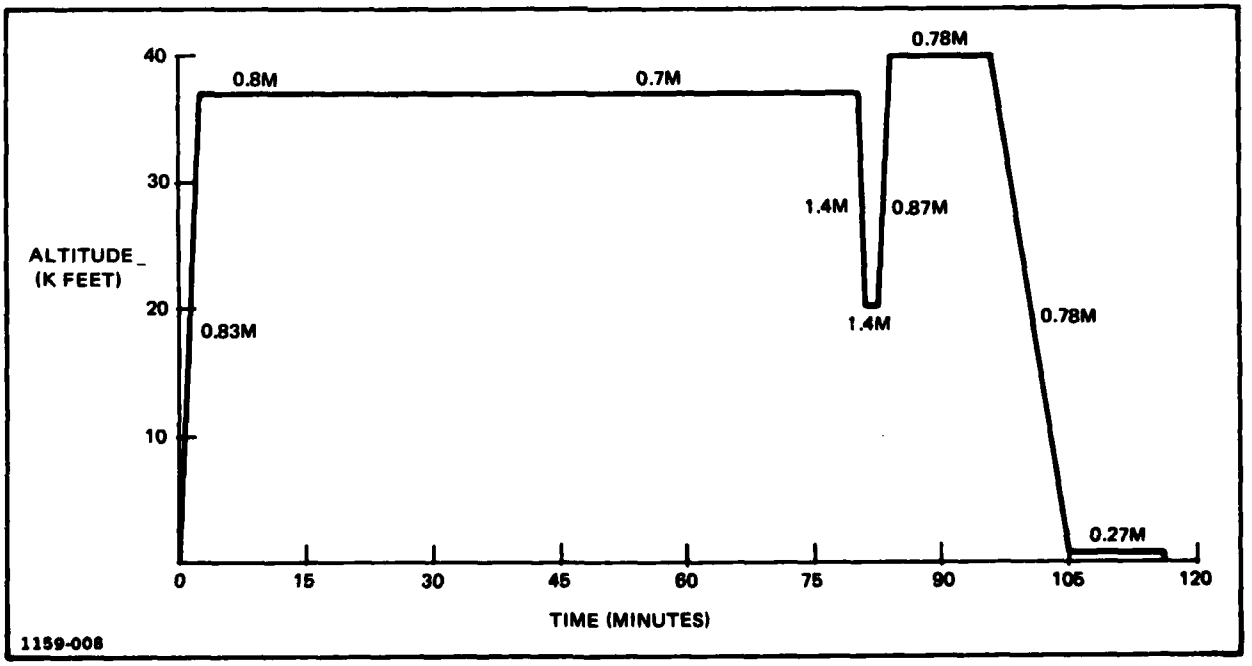


Figure 8 "B" V/STOL Combat Air Patrol Mission Profile

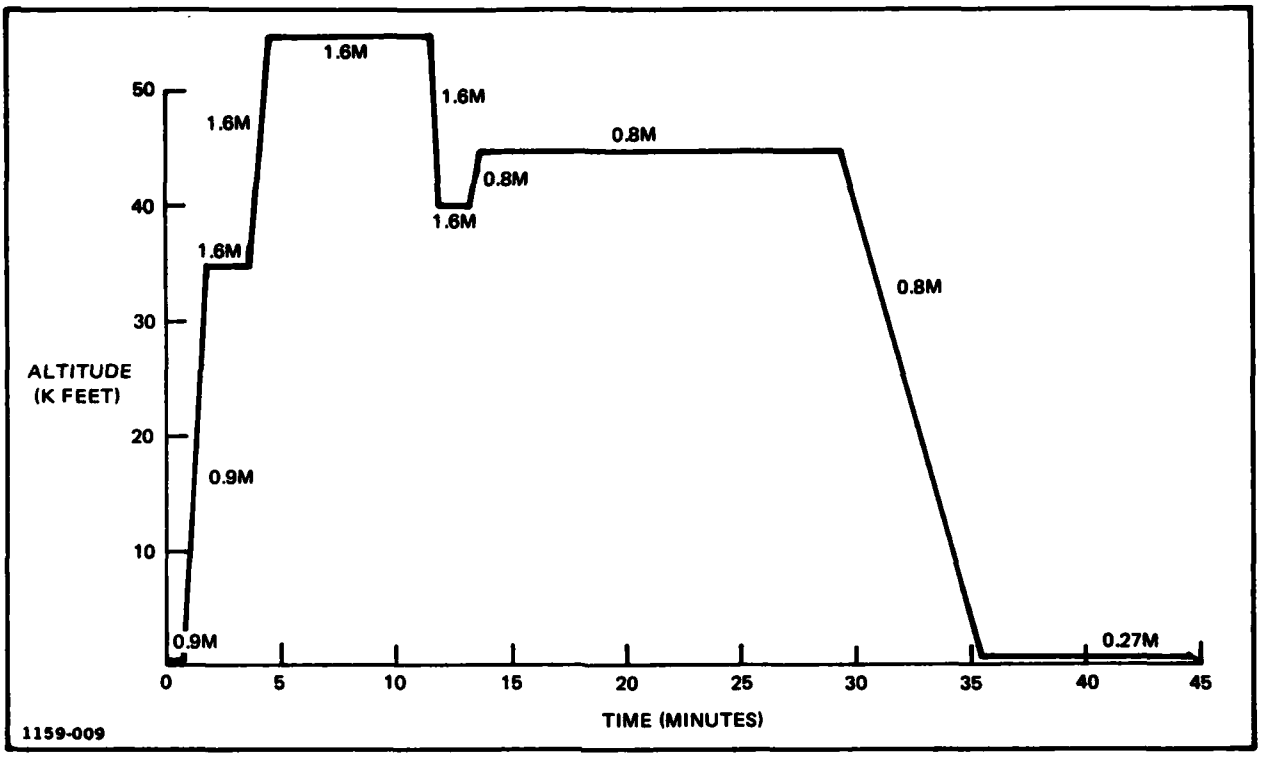


Figure 9 "B" V/STOL Deck Launched Intercept Mission Profile

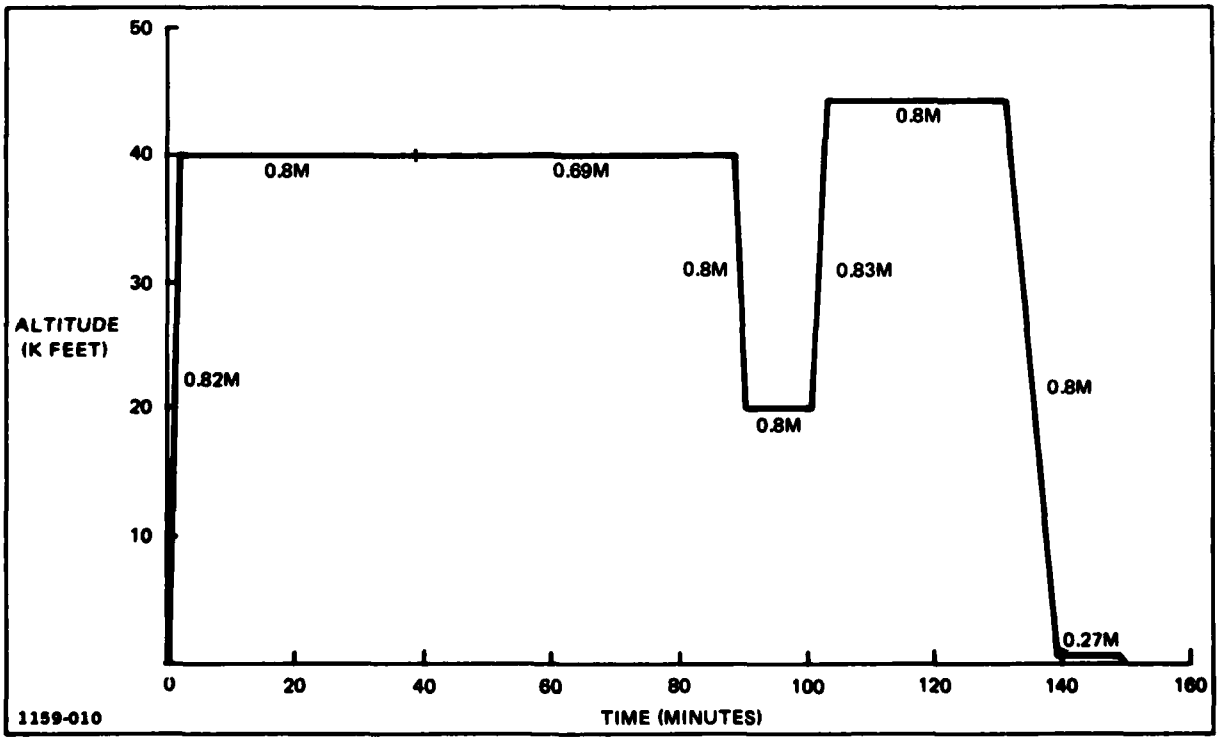


Figure 10 "B" V/STOL Subsonic Surface Surveillance Mission Profile

Section 3

ENVIRONMENTAL CONSIDERATIONS

3.1 Introduction

The study conducted by Grumman Aerospace Corporation to evaluate environmental profiles for testing equipment installed in Naval aircraft (see reference) established a methodology for defining thermal and vibration levels and exposure durations for conventional aircraft. During this study both of these environmental parameters were investigated for V/STOL vehicles to determine whether significant differences did exist and to provide a means for including these differences in V/STOL test profiles.

3.2 Thermal

The thermal evaluations conducted indicate that no significant temperature differences exist between conventional and V/STOL aircraft and the methodology described in the reference can be utilized to establish thermal test profiles. The tables listing compartment temperature as a function of altitude and Mach No., also encompass the speed and altitude of V/STOL aircraft. In order to maximize equipment reliability, V/STOL designs will include cooling systems and techniques designed to maintain "cool" ambient conditions for electronic hardware. Therefore, due to this philosophy of design, the vast majority of equipment will enjoy a "cockpit" or Class I thermal environment.

3.3 Vibration

Vibration effects on equipment for V/STOL aircraft operating in a horizontal flight mode are identical to those experienced by conventional fixed wing aircraft. However, for vertical flight modes (take-off/landing) the vibration levels, due to ground effects, are significantly different.

Reference: Evaluation of Environmental Profiles for Testing Equipment Installed in Naval Aircraft, Grumman Report No. RMS-79-R-1, dated February 1979.

Table 1, an abridged version of Table B-8 in the reference, has been developed for V/STOL use and includes new vibration test levels (W_o) for V/STOL peculiar take-off/landing conditions.

The take-off/landing W_o values have been calculated in accordance with MIL-STD-810C, Table 514.2-IIA, using V/STOL engine parameter information. These calculations have been performed for both V/STOL "A" and V/STOL "B" type aircraft.

TABLE 1. V/STOL AIRCRAFT – RANDOM VIBRATION TEST

AEROSPACE INDUCED VIBRATION

$W_o = K(q)^2$, WHERE q = DYNAMIC PRESSURE (WHEN q > 1200 psf USE 1200).
$W_1 = W_o - 3$ dB

K	EQUIPMENT LOCATION
0.67×10^{-8}	EQUIPMENT ATTACHED TO STRUCTURE ADJACENT TO EXTERNAL SURFACES THAT ARE SMOOTH, FREE FROM DISCONTINUITIES
0.34×10^{-8}	COCKPIT EQUIPMENT AND EQUIPMENT IN COMPARTMENTS AND ON SHELVES ADJACENT TO EXTERNAL SURFACES THAT ARE SMOOTH, FREE FROM DISCONTINUITIES
3.5×10^{-8}	EQUIPMENT ATTACHED TO STRUCTURE ADJACENT TO OR IMMEDIATELY AFT OF SURFACES HAVING DISCONTINUITIES (THAT IS, CAVITIES, CHINS, BLADE ANTENNAS, ETC.)
1.75×10^{-8}	EQUIPMENT IN COMPARTMENTS ADJACENT TO OR IMMEDIATELY AFT OF SURFACES HAVING DISCONTINUITIES (THAT IS, CAVITIES, CHINS, SPEED BRAKES, ETC.)

SPECIAL CASE CONDITIONS

CONDITION/EQUIPMENT LOCATION	W_o (HOR)	W_o (VERT) V/STOL "A"	W_o (VERT) V/STOL "B"
TAKE-OFF*/ATTACHED TO OR IN COMPARTMENTS ADJACENT TO STRUCTURE DIRECTLY EXPOSED TO ENGINE EXHAUST AFT OF ENGINE EXHAUST PLANE (1 MINUTE**).	0.7	0.06	0.60
TAKE-OFF*/IN ENGINE COMPARTMENT OR ADJACENT TO ENGINE FORWARD 0.1 OF ENGINE EXHAUST PLANE (1 MINUTE**).	0.1	0.17	0.04
TAKE-OFF*/ALL OTHER LOCATIONS (1 MINUTE**).	0.002	0.02	0.02

*TAKE-OFF OR LANDING
**0.5 MINUTE FOR VERTICAL TAKE-OFF/LANDING MODE

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Section 4

TEST PROFILES

The test profiles developed during this study were generated utilizing the methodology described in the reference. All ground rules, as well as thermal and vibration criteria delineated in that Grumman report were also applicable to both V/STOL "A" and "B" in horizontal flight modes.

Table 1, "V/STOL Aircraft Random Vibration Test" criteria were reworked to include vertical flight modes (W_o values). In addition, the duration for vertical take-off or landing was assumed to be 0.5 minute to reflect anticipated V/STOL conditions.

It was also assumed that all electronic equipment would be located in compartments forward of the engine.

Since the thermal design philosophy for V/STOL hardware was to maintain a "cool" ambient temperature, the thermal profiles reflect a Class I environmental condition.

The test profiles for V/STOL "A" aircraft are presented in Figures 11 through 17. Figures 18 through 20 depict the test profiles for the V/STOL "B" configuration.

Reference: Evaluation of Environmental Profiles for Testing Equipment Installed in Naval Aircraft, Grumman Report No. RMS-79-R-1, dated February 1979.

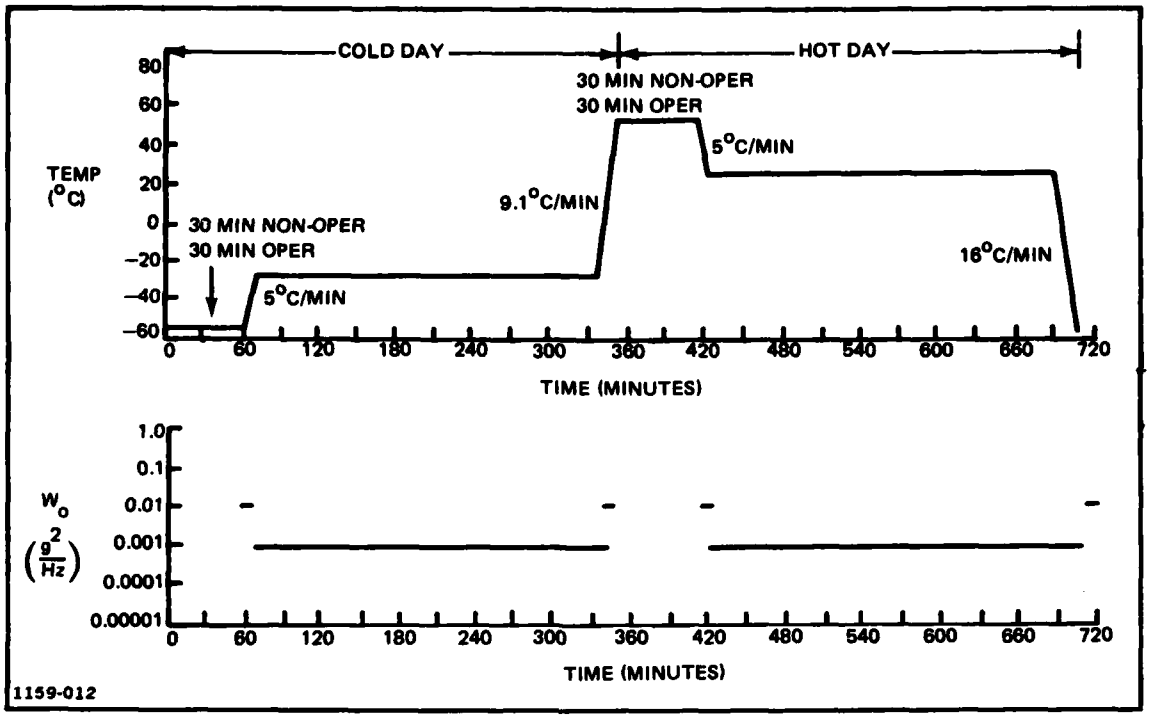

Figure 11 "A" V/STOL Airborne Early Warning Environmental Profile

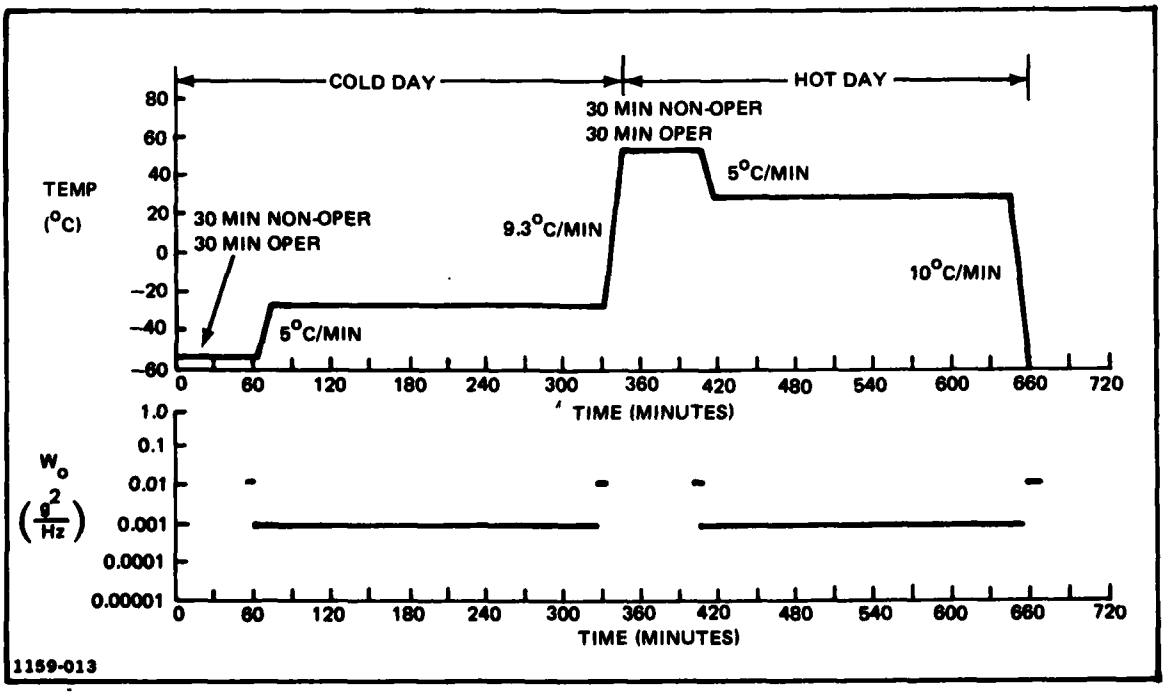

Figure 12 "A" V/STOL Anti-submarine Warfare Environmental Profile

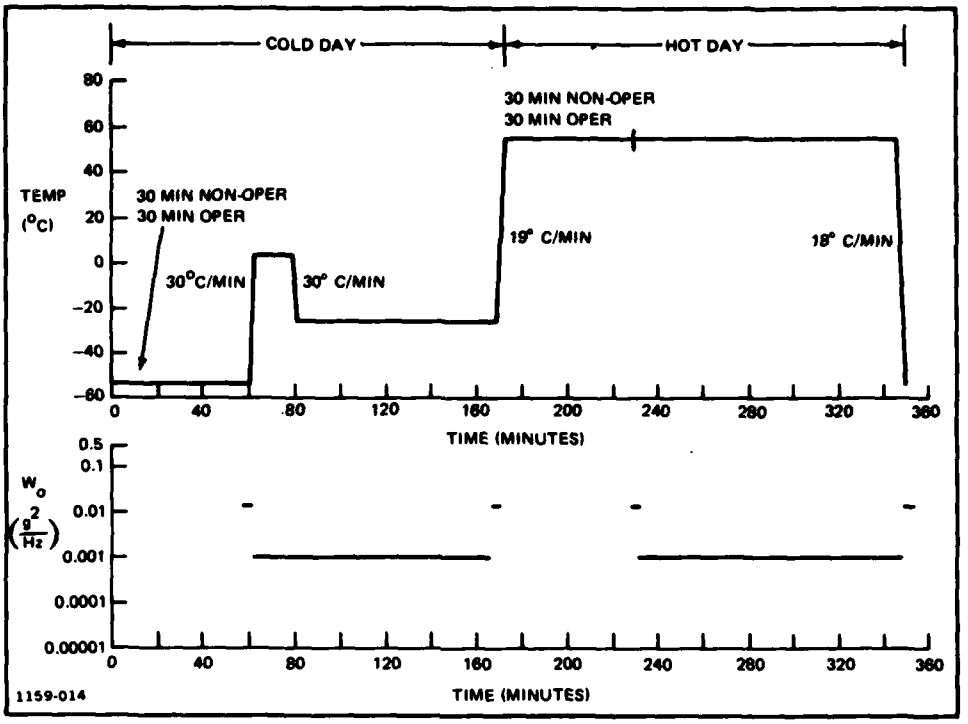

Figure 13 "A" V/STOL Contact Investigation Environmental Profile

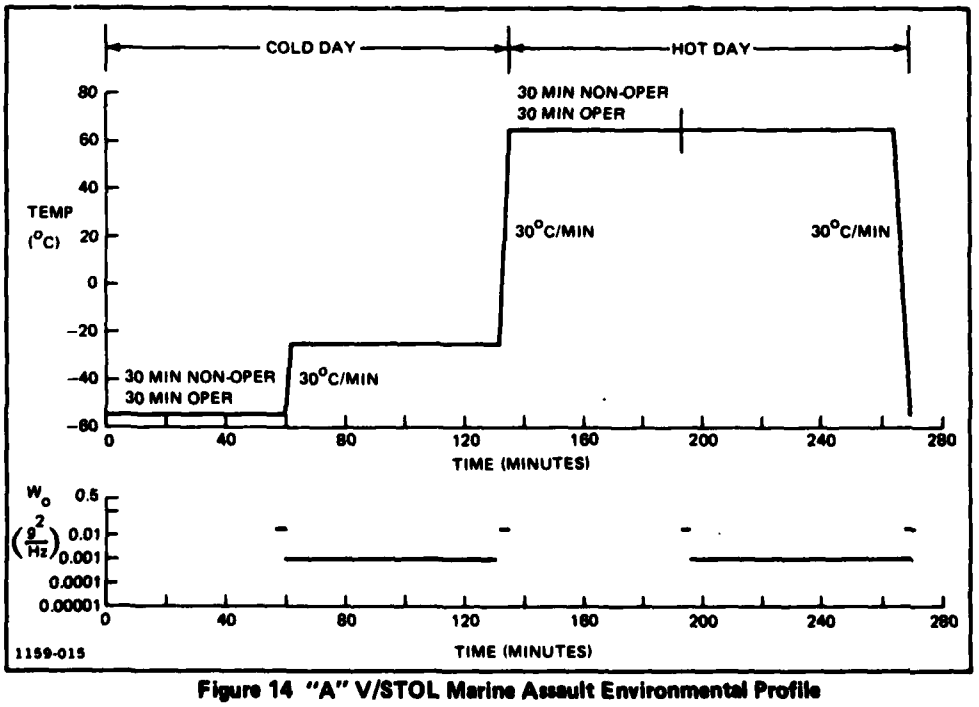

Figure 14 "A" V/STOL Marine Assault Environmental Profile

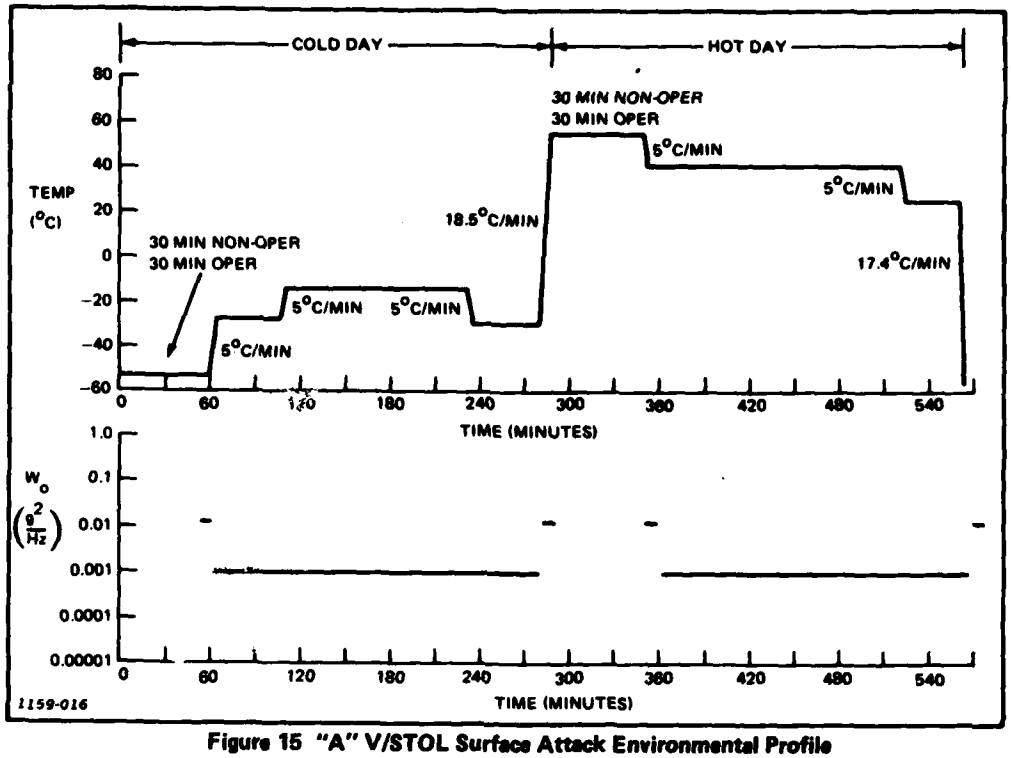

Figure 15 "A" V/STOL Surface Attack Environmental Profile

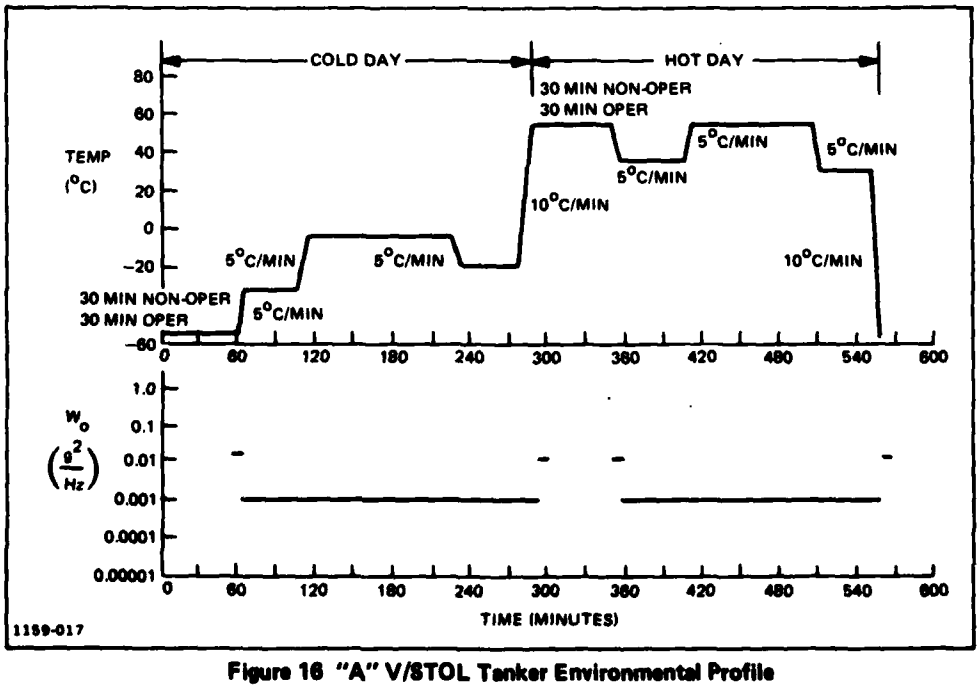

Figure 16 "A" V/STOL Tanker Environmental Profile

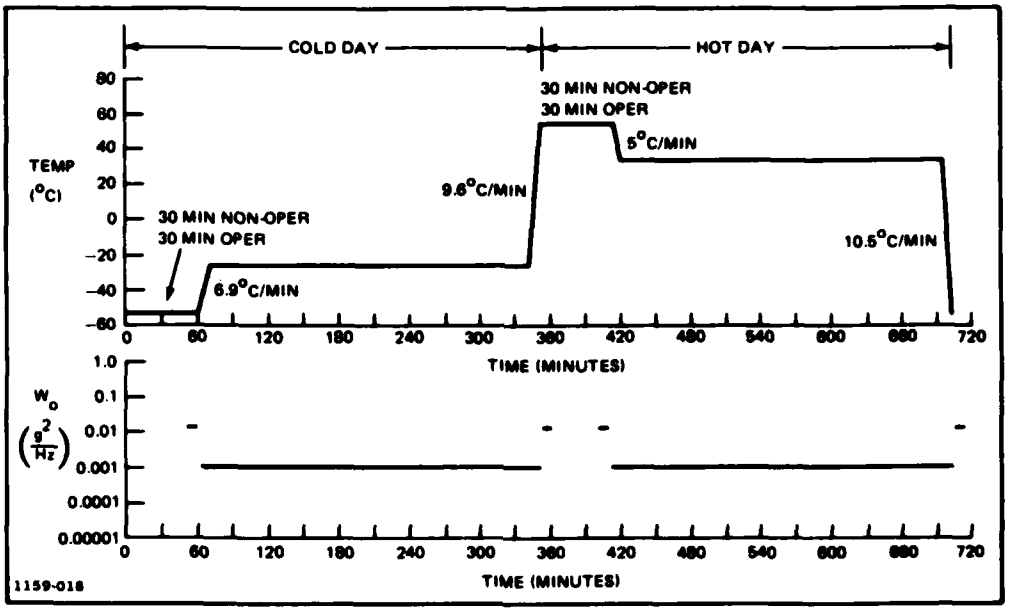

Figure 17 "A" V/STOL Vertical Onboard Delivery Environmental Profile

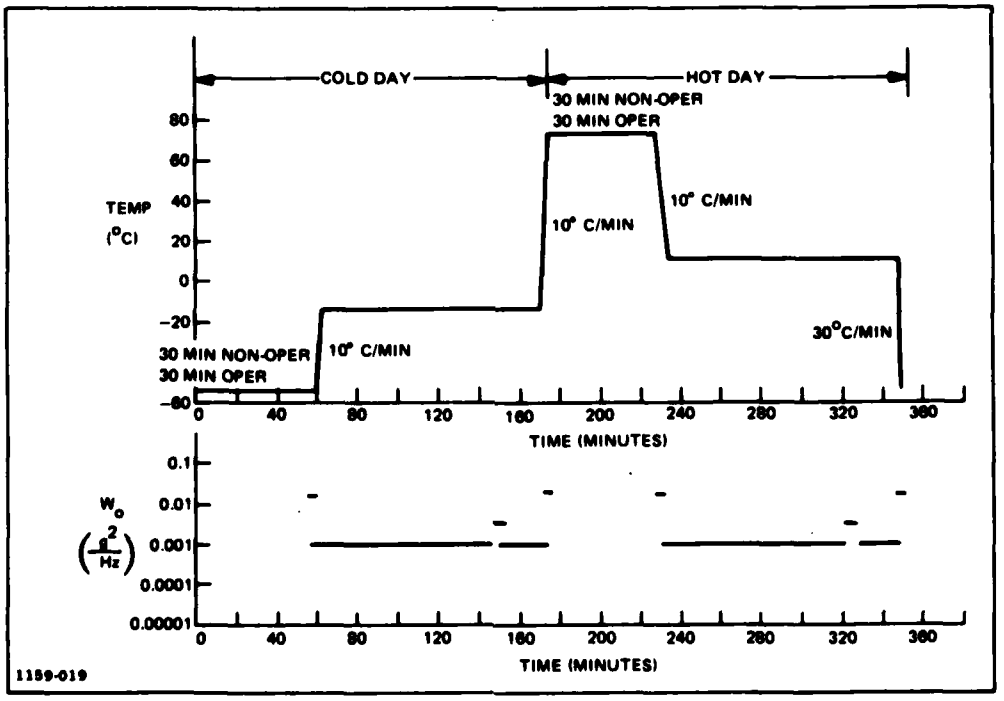

Figure 18 "B" V/STOL Combat Air Patrol Environment Profile

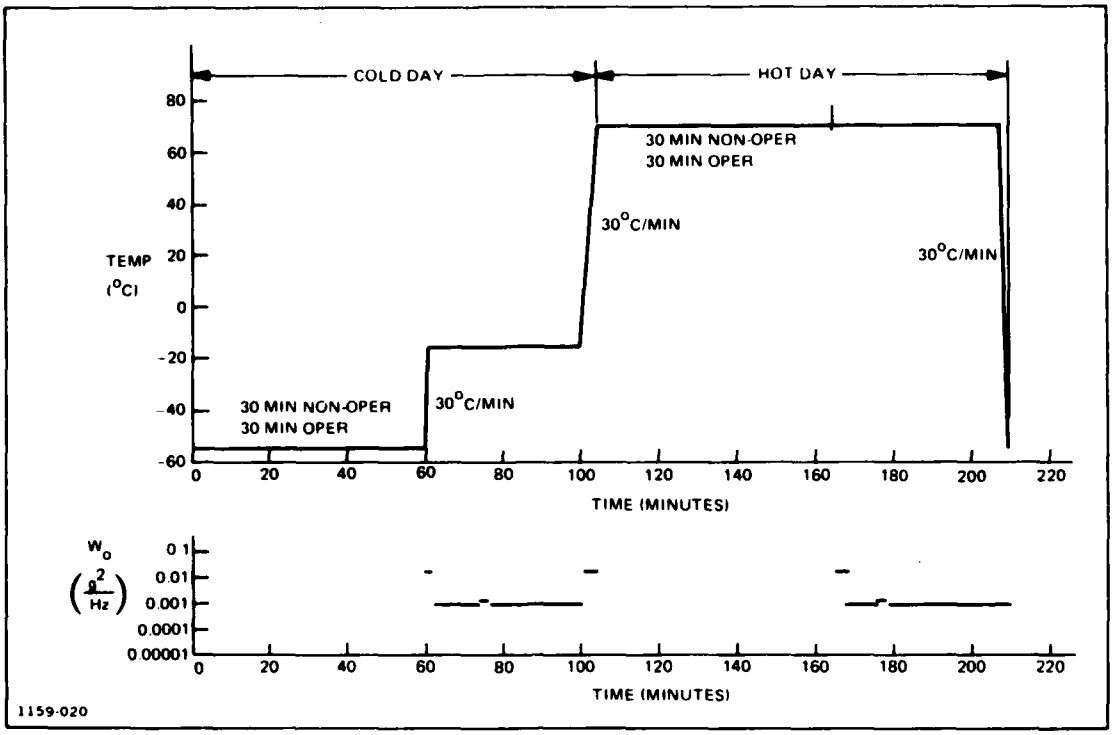

Figure 19 "B" V/STOL Deck Launched Intercept Environmental Profile

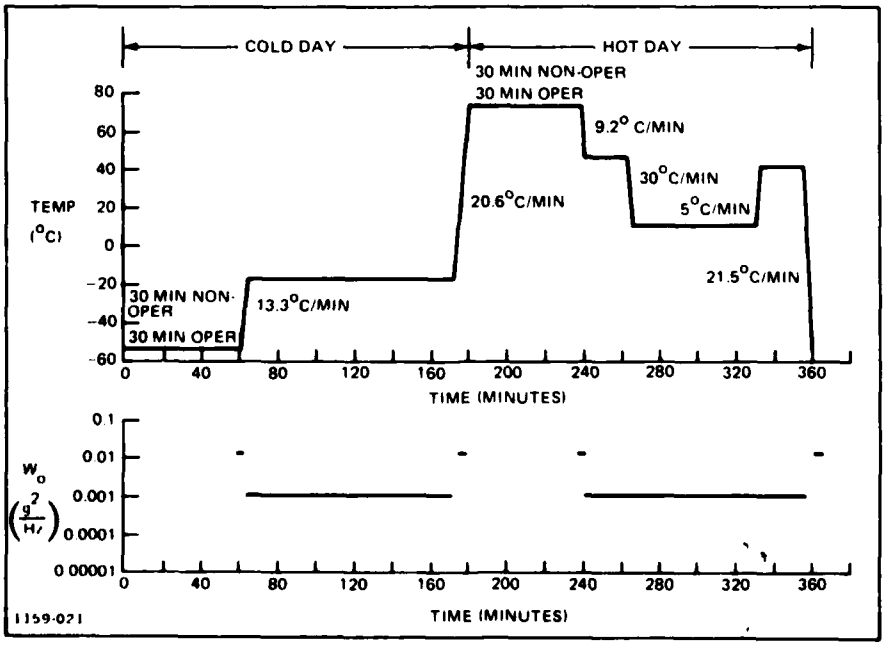

Figure 20 "B" V/STOL Substonic Surface Surveillance Environmental Profile